銀河中心および反中心方向のアーム距離決定

dv/dl法

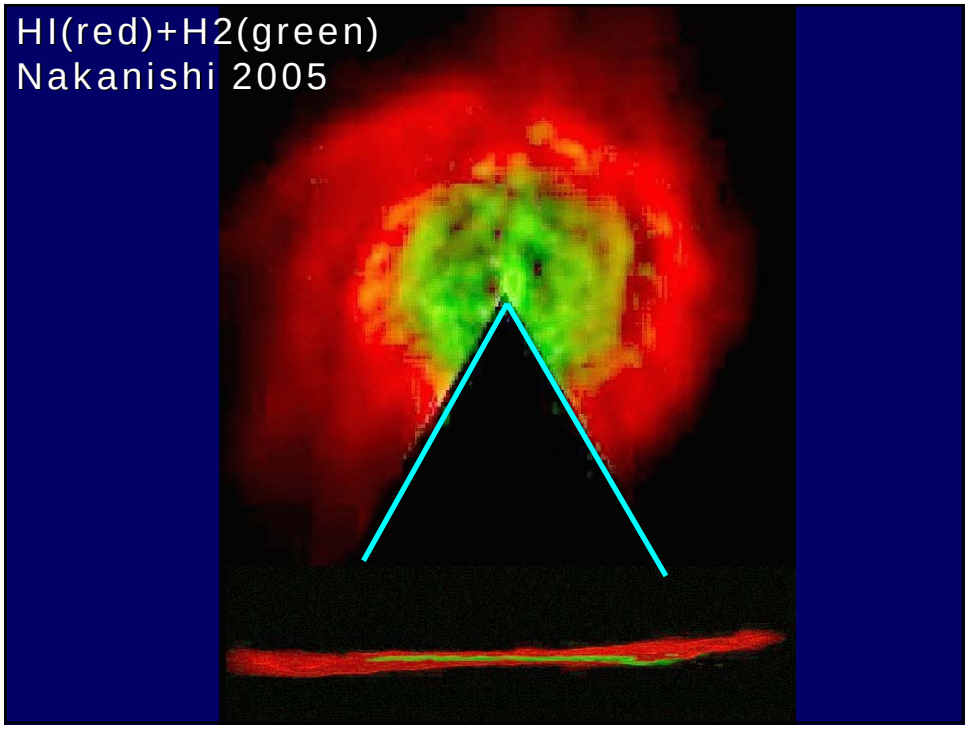
祖父江義明
東大理
2006年2月21日

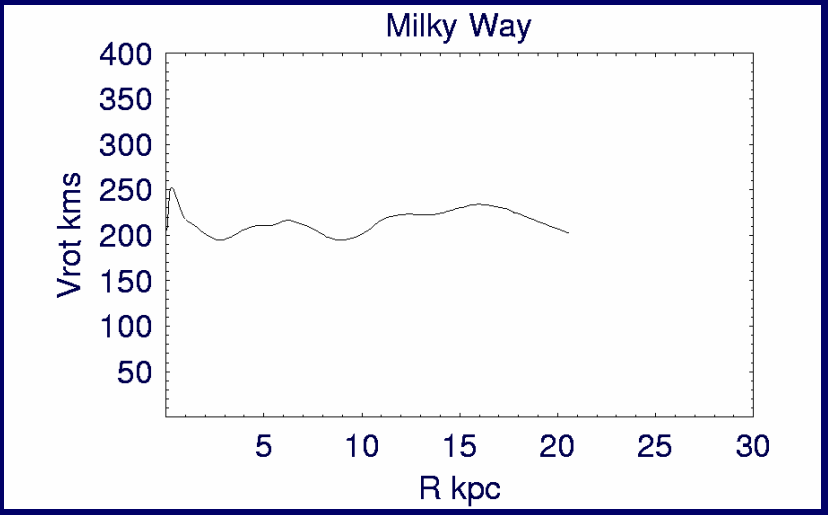
回転速度場から星間物質の分布を求める

V→R法

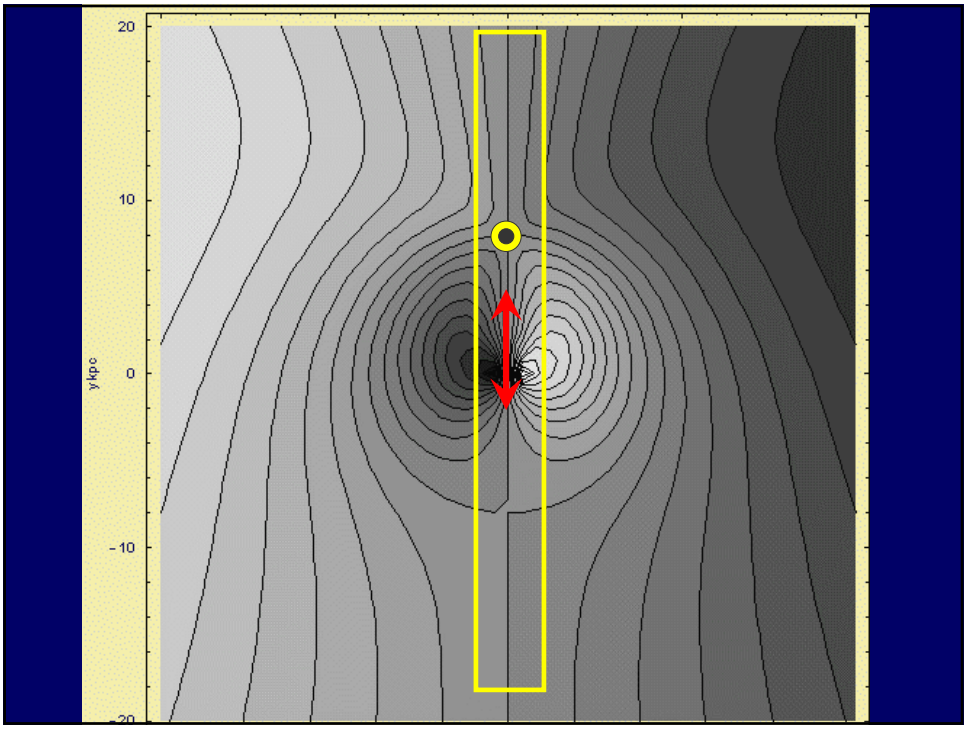
Velo-to-Space Transform

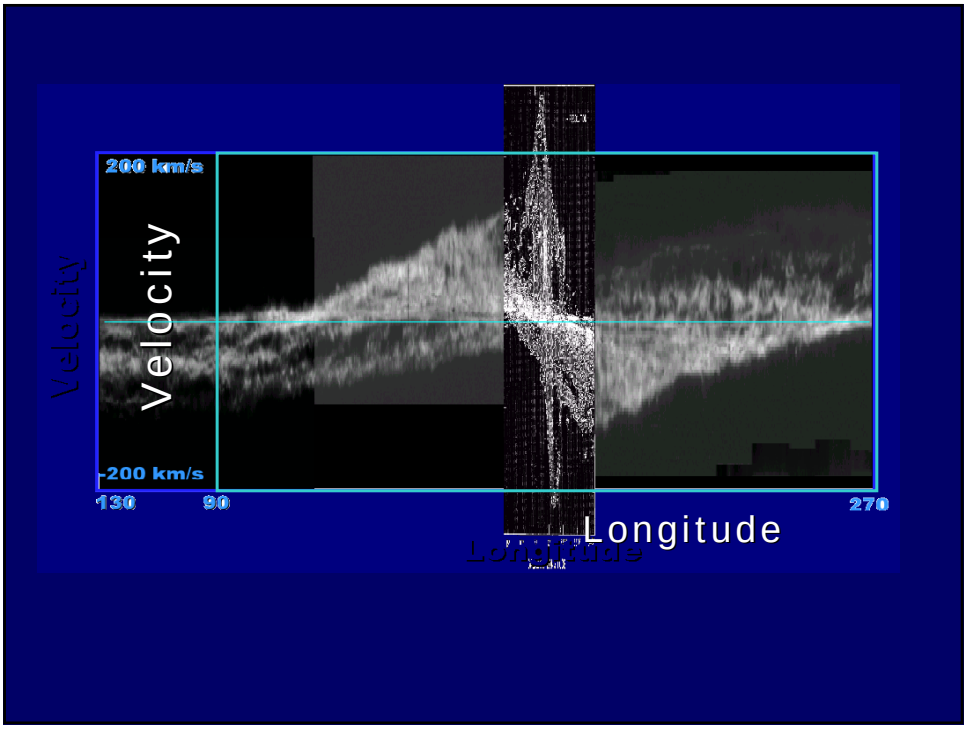
GC－太陽間で
測度＝0に縮退して
距離不確定

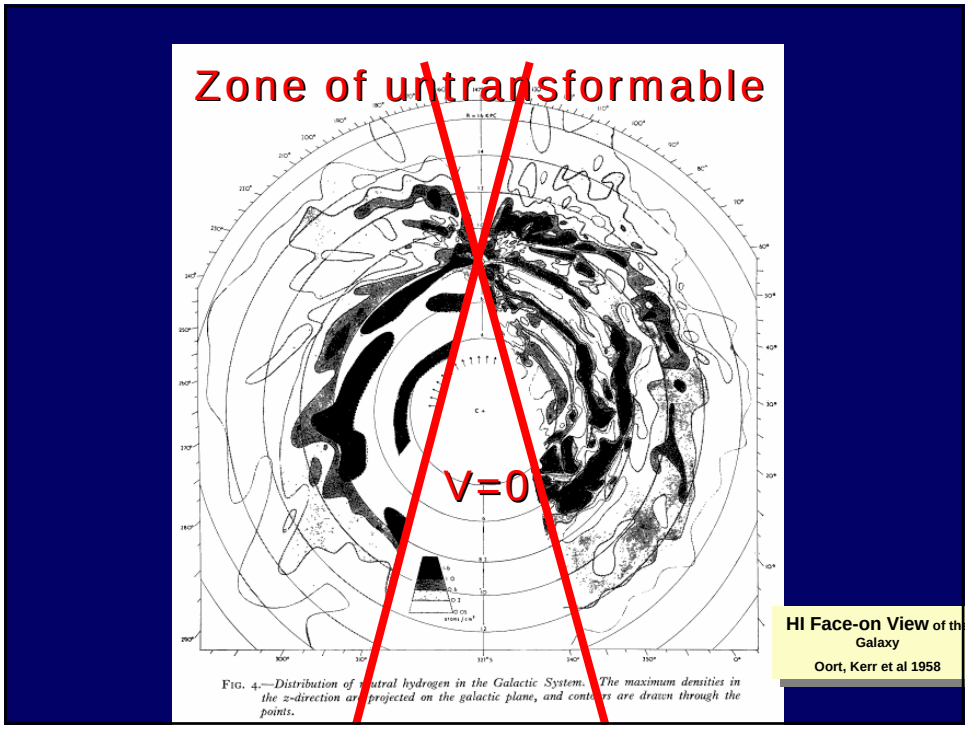




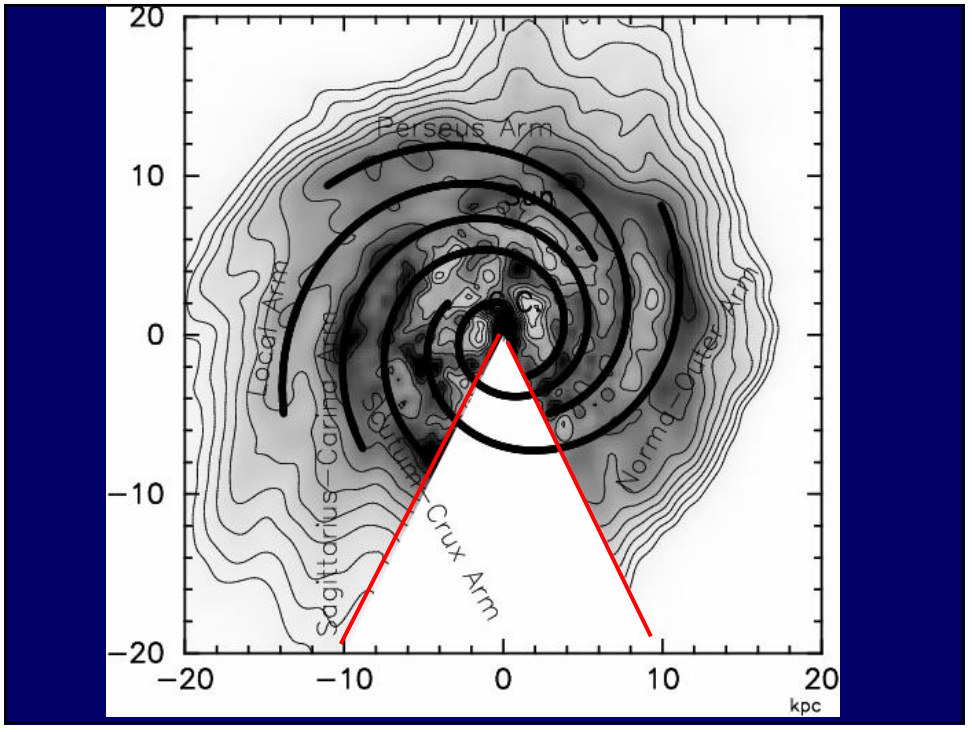
$$v = R_0(\omega - \omega_0)\sin\ l = \left\{\frac{R_0}{R}V - V_0\right\}\sin\ l,$$


20
10
0
-10
-20
y Kpc


200 km/s
Velocity
-200 km/s
130
90
270
Longitude



HI Face-on View of th
Galaxy
Oort, Kerr et al 1958

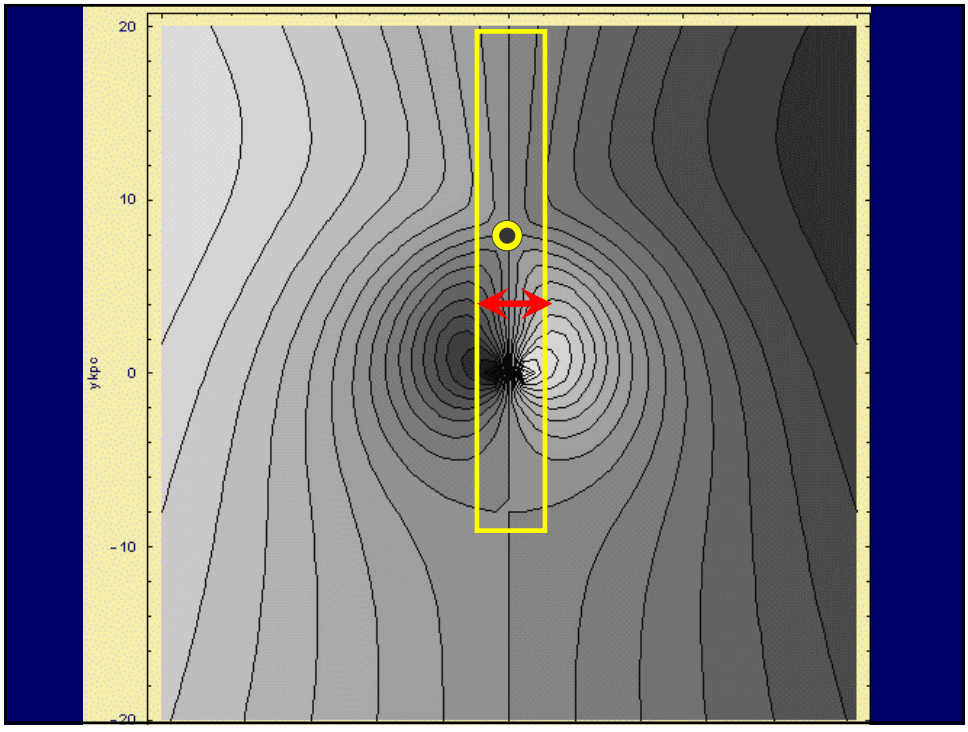


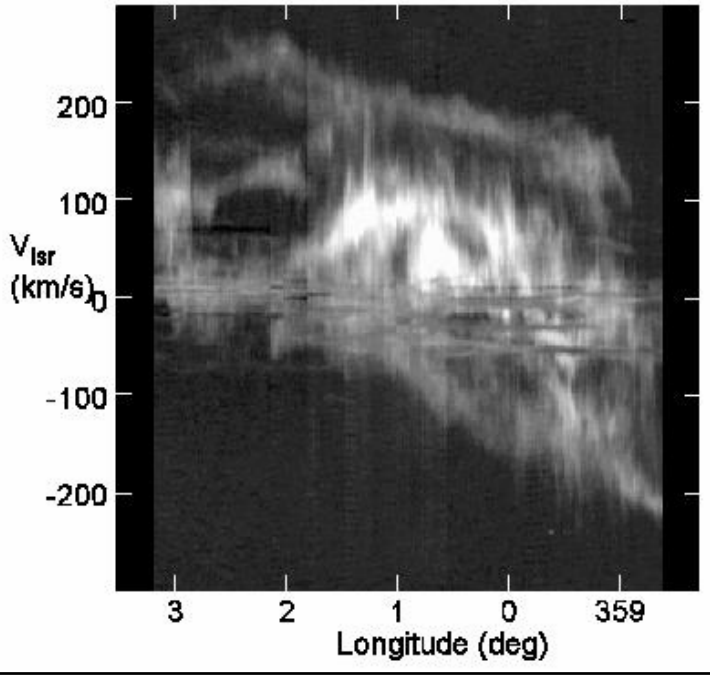
dv/dl 法

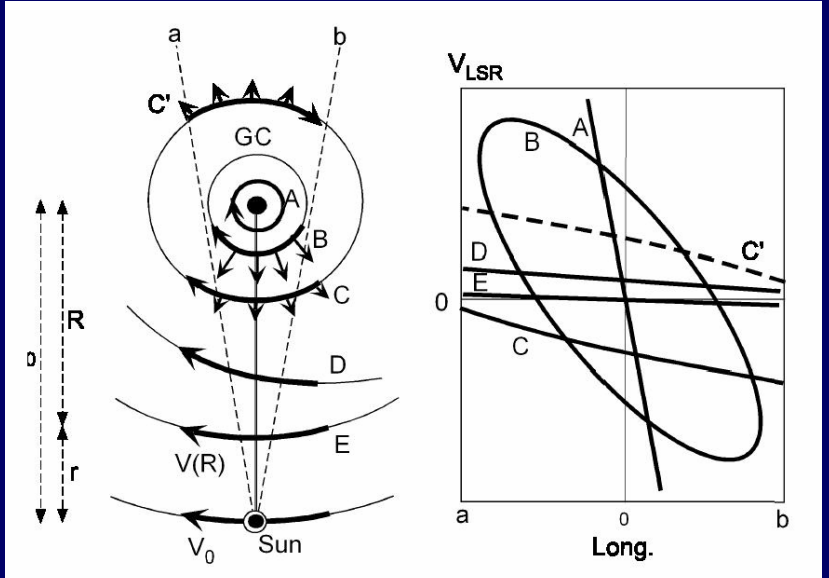
New !

ＧＣ－太陽間で距離決定

ただしArm (ridge)のみ




200
100
V_{lsr}
(km/s)
0
-100
-200
3
2
1
0
359
Longitude (deg)


a
b
C'
GC
A
B
C
D
E
R
r
V(R)
V_0
Sun
V_{LSR}
A
B
C'
D
E
0
C
a
0
b
Long.

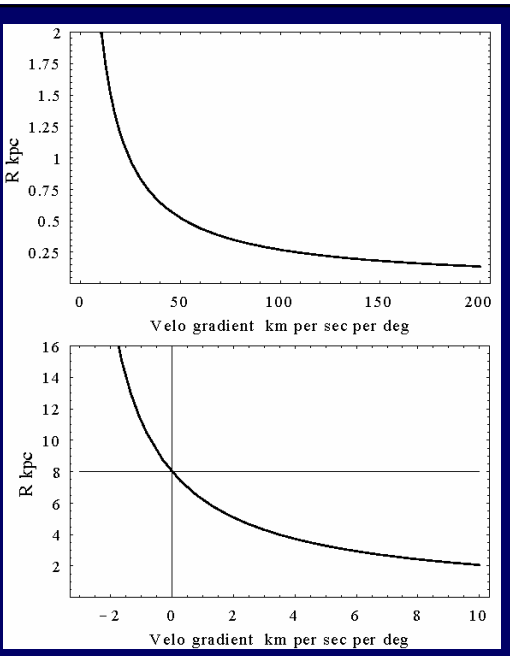
$$v = R_0(\omega - \omega_0)\sin\ l = \left\{\frac{R_0}{R}V - V_0\right\}\sin\ l,$$

$$\frac{dv}{dl} = \frac{R_0}{R}(V\ \cos\ l + 2Ar\ \tan\ p\ \sin\ l) - V_0\ \cos\ l,$$

$$R = R_0\left(V_0\cos\ l + \frac{dv}{dl}\right)^{-1}(V\ \cos\ l - 2Ar\ \tan\ p\ \sin\ l).$$

$$R = R_0\frac{V}{V_0}\left(1 \pm \frac{1}{V_0}\frac{dv}{dl}\right)^{-1},$$

Approximate
R for V=V0

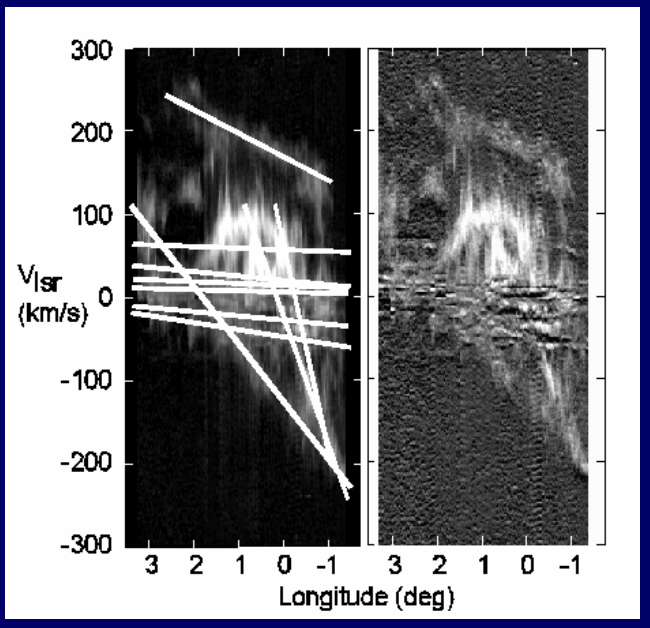


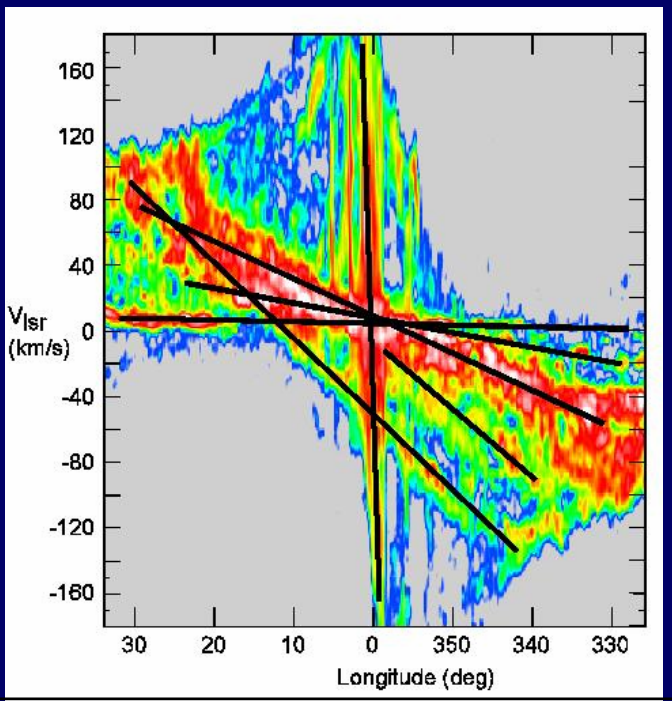
dv/dl

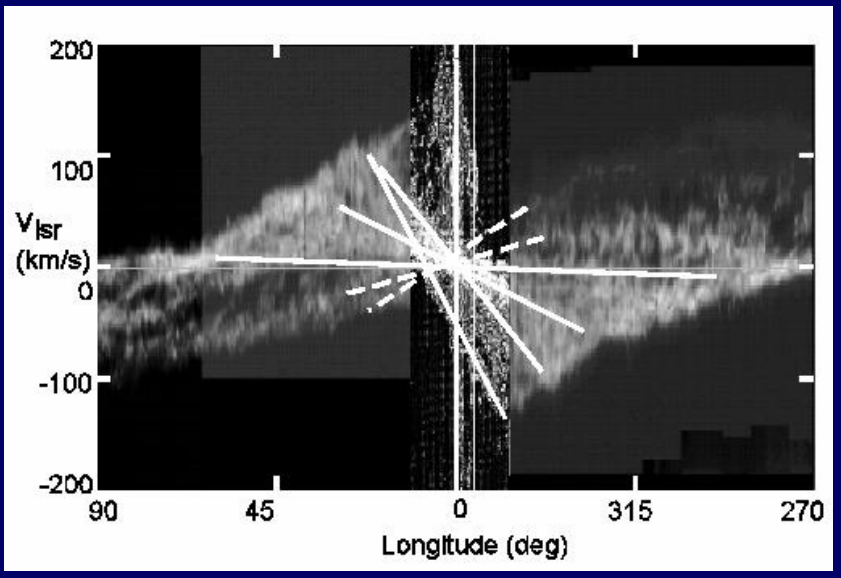
Contributions to dv/dl by

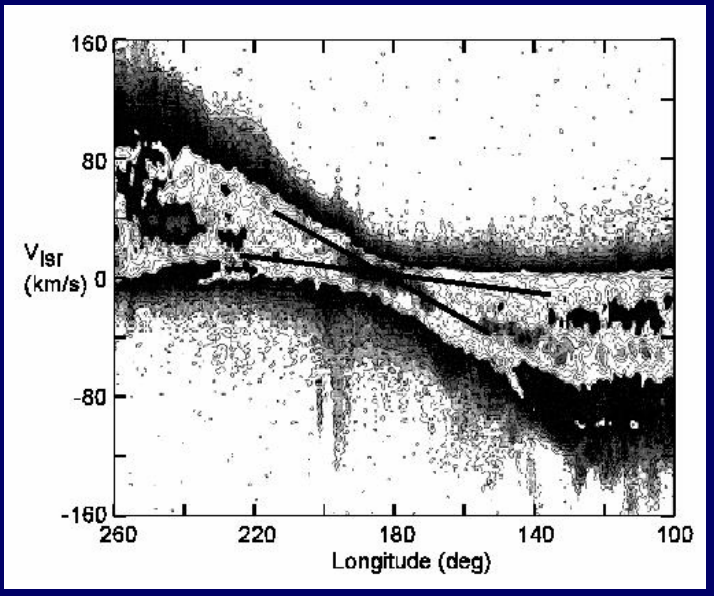
Non-circular motion
Streaming motion
Expanding motion
Contraction
Random motion of clouds

are << |dv/dl | by circular rotation


300
200
100
0
-100
-200
-300
V_{lsr}
(km/s)
3 2 1 0 -1
3 2 1 0 -1
Longitude (deg)


160
120
80
40
0
-40
-80
-120
-160
V_{lsr}
(km/s)
30 20 10 0 350 340 330
Longitude (deg)

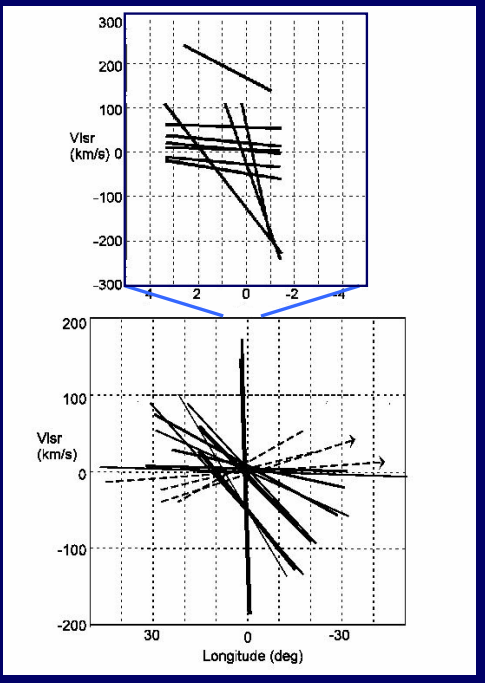

200
100
V_{lsr}
(km/s)
0
-100
-200
90
45
0
315
270
Longitude (deg)


160
80
V_{lsr}
(km/s)
0
-80
-160
260
220
180
140
100
Longitude (deg)

LV Slope

dv/dl

[km/s/degree]



$$R = R_0 \frac{V}{V_0} \left(1 \pm \frac{1}{V_0} \frac{dv}{dl}\right)^{-1},$$

$$R = R_0 \left(\frac{V}{200\text{km s}^{-1}}\right) \left(1 \pm 0.286 \frac{dv}{dl^\circ}\right)^{-1} \text{[kpc]},$$

Iteration:

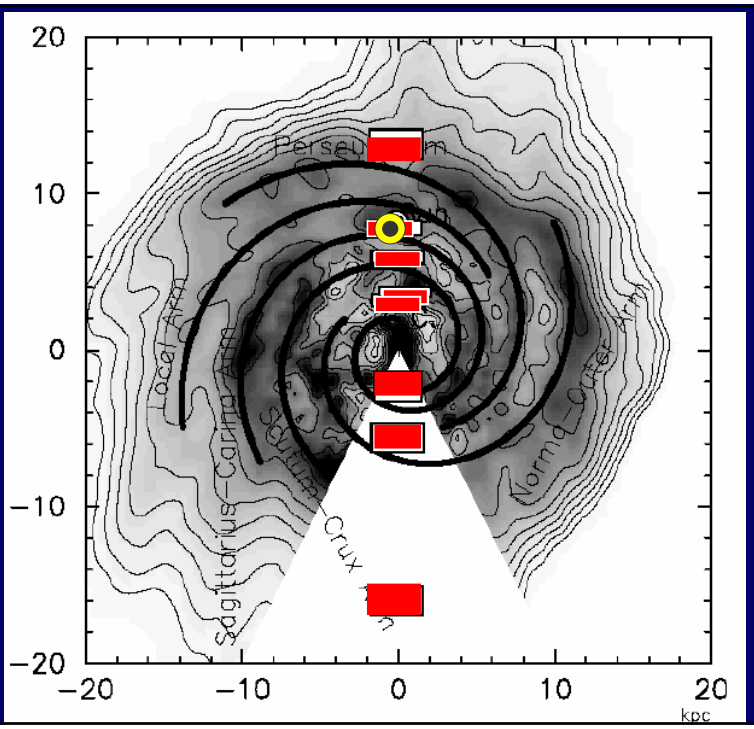
$V=V_0$, R, V=V(R), R, V=V(R), …., R (final)

Iteration result

dv/dl° (km s^{-1} deg^{-1})	radial velocity (km s^{-1})	R (kpc)	Iterated R_i (kpc)	$r = 8.0 - R$ (kpc)
CO LV ridges in figure 6a				
1.4	6.5	5.7	$R_4 = 6.5$	2.5
2.1	15	5.0	$R_4 = 5.6$	2.4
5.1	21	3.3	$R_2 = 3.3$	4.7
4.9	-27	3.3	$R_2 = 3.3$	4.7
8.6	47	2.3	$R_2 = 2.3$	5.7
2.0	57	5.1	$R_3 = 5.7$	2.3
152	-30	0.18	$R_4 = 0.28$	7.72
250	60	0.11	$R_5 = 0.15$	7.85
71	-131	0.37	$R_4 = 0.54$	7.46
2.8	170	0.89	$R_4 = 0.26$	7.74
CO and HI LV ridges in figure 6b				
0.10	4.6	7.8	$R_1 = 7.8$	0.2
0.12	0.7	7.7	$R_1 = 7.7$	0.3
0.89	7.5	6.4	$R_6 = 7.1$	0.9
1.82	1.2	5.3	$R_6 = 6.1$	1.9
2.23	8.4	4.9	$R_3 = 5.4$	2.6
4.1	-5.1	3.7	$R_5 = 3.9$	4.1
4.4	4.0	3.5	$R_4 = 3.6$	4.4
4.6	-52	3.5	$R_2 = 3.5$	4.5
4.9	-50	3.3	$R_4 = 3.2$	4.8
6.8	-49	2.7	$R_2 = 2.6$	5.7
-1.1	4.8	11.7	$R_8 = 16$	8
-2.31	13.0	23.6	$R_3 = 24$	8
-0.28	0.4	8.7	$R_3 = 8.4$	0.6
-0.88	8.3	10.7	$R_4 = 13.2$	2.8

Arm identification

Radial velocity (km s^{-1})	Iterated R_i (kpc)	Arm identification[†]
-30	0.28	GC molecular ring: Arm I (Sofue 1995a)
60	0.15	GC molecular ring: Arm II
-131	0.54	GC expanding ring
170	0.26	
-52	3.5	3-kpc Expanding ring
-50	3.2	
-49	2.6	
-27	3.3	
-45 ± 12	3.1 ± 0.4	
47	2.3	Expanding Ring beyond GC
57	5.7	
-5.1	3.9	4-kpc molecular ring
4.0	3.6	
21	3.3	
6.6 ± 13	3.6 ± 0.3	
8.4	5.4	Scutum-Crux arm
1.2	6.1	
6.5	6.5	
15	5.6	
7.8 ± 5.6	5.9 ± 0.5	
7.5	7.1	Sgr-Carina/Local arm
0.7	7.7	
4.6	7.8	
0.4	8.4	
3.3 ± 3.4	7.75 ± 0.5	
8.3	13	Perseus arm
4.8	16	Outer arm beyond GC
13.0	24	Outermost arm beyond GC



Discrepancy between known arms and Present arm positions is due to different RCs

この論文の評価Referee's comment

It's debatable whether this paper is orthy of publication since the transformation of Galactic rings into LV lines has been common knowledge among galactic astronomers for decades and much more general model fits of spiral loops in CO and HI LV diagrams have been carried out by many researchers over the past fifty years. The fitting in the present paper can be considered rather myopic in the sense that it fits only small sections of arms toward the center and anti-center.

Still, since I know of no other study that discusses specifically the use of stripe slopes as distance indicators in directions commonly considered to be the most difficult for distance determination, I recommend publication after the discussion of the various effects that can modify the slope of a stripe is made more rigorous.